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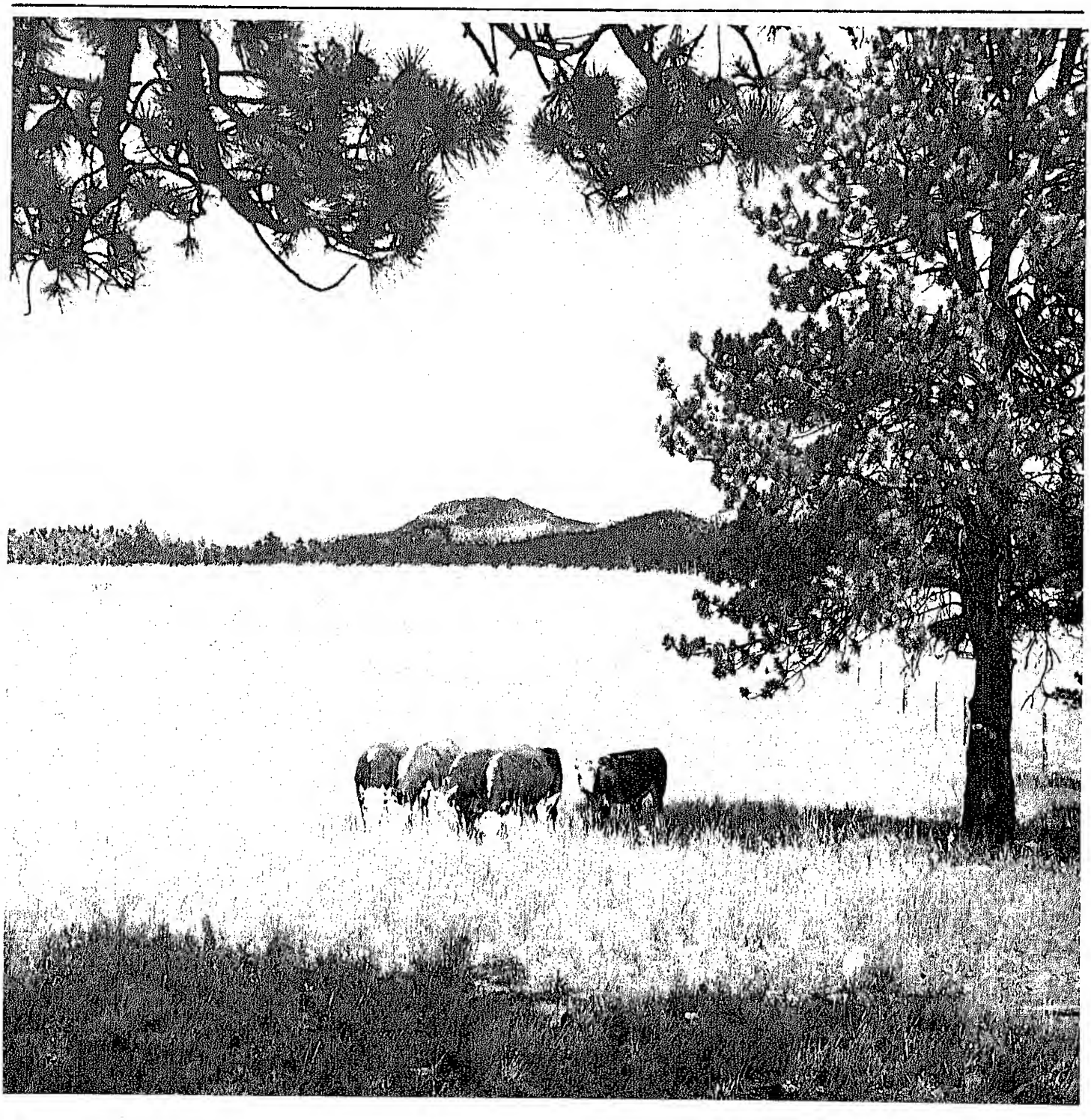
Forestry Research West



A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

Forestry Research West

In This Issue

Cover

The Rocky Mountain Station has just published a series of reports that summarize the "state-of-the-art" of resource management planning techniques. The first in the series covers ecological factors that affect forage production on forest and rangeland ecosystems. Reviews of these publications begin on the facing page.

To Order Publications

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Western Forest Experiment Stations

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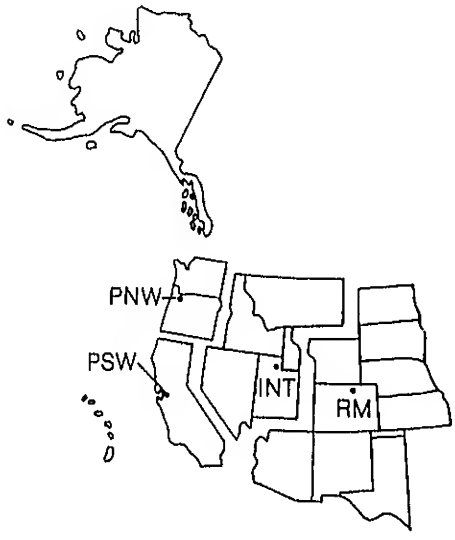
P.O. Box 245
Berkeley, California 94701

Intermountain Forest and Range Experiment Station (INT)
507 25th Street
Ogden, Utah 84401

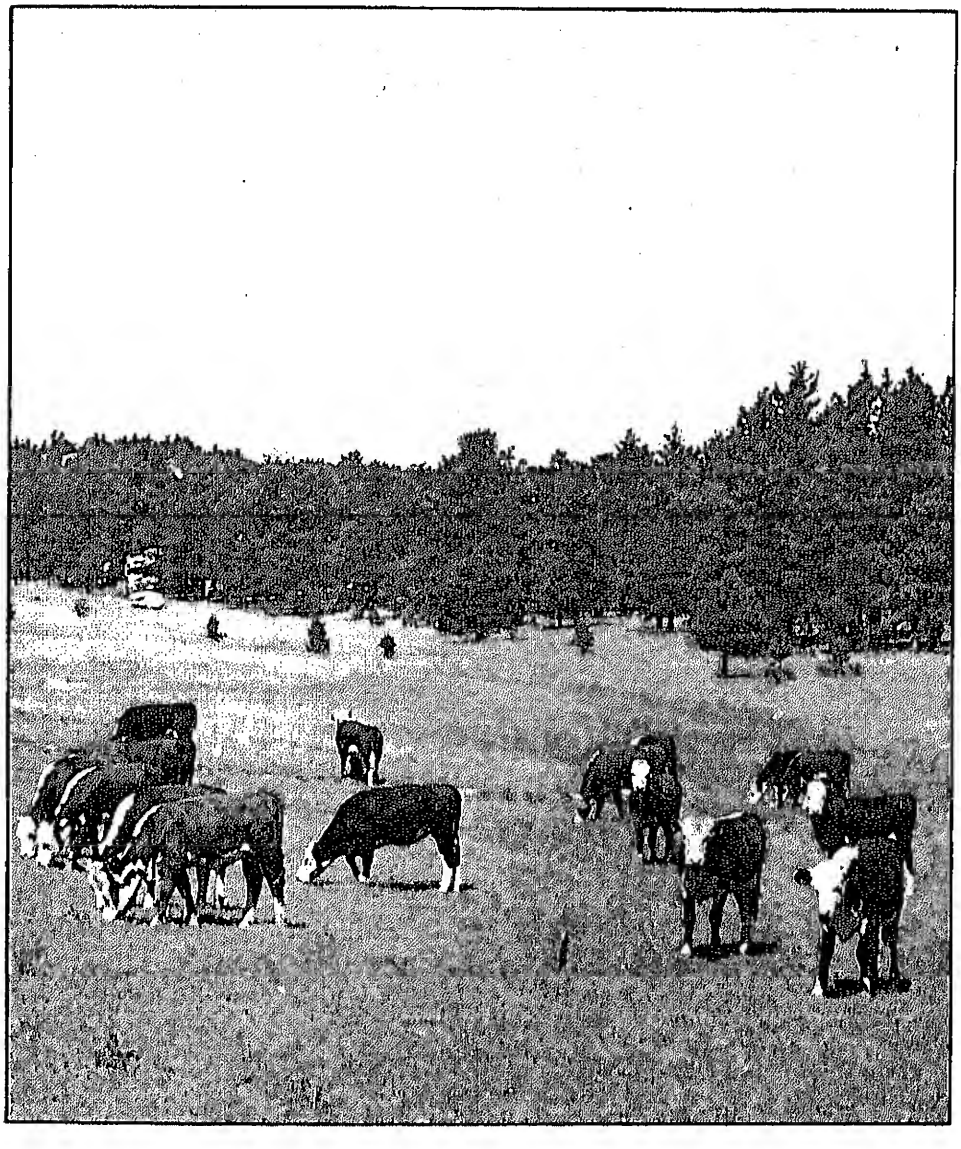
Rocky Mountain Forest and Range Experiment Station (RM)
240 West Prospect Street
Fort Collins, Colorado 80526



New status of knowledge series issued

by Rick Fletcher
Rocky Mountain Station

One of the newest projects at the Rocky Mountain Station, titled land and Resource Management Planning Techniques, is concerned with: designing and improving procedures to develop and analyze land management alternatives; developing methods to predict how production of renewable resources would respond to various land management activities; and improving procedures to predict social and economic impacts of alternative land management plans.



Project Leader Thomas W. Hoekstra says, "In order to establish a base from which to begin our research, we needed to know the state-of-the-art of resource management planning techniques. As a result, project scientists have compiled and summarized material from a variety of sources that has resulted in five new reports. The following is a brief review of each. All are either currently available or will be soon from the Rocky Mountain Station (see publications ordering cards inside this issue).

The first paper covers the ecological factors, including human activities, that affect forage production on forest and rangeland ecosystems. Its purpose is twofold: (1) to compile information necessary to describe production mechanisms for ecological modeling, and (2) to place such information in a format that can be easily synthesized. Also discussed are a review of forage production models, and how forage quality and quantity can control animal production.

In addition, this paper provides readers who are familiar with basic concepts of ecology with a contemporary picture of what forage production is and how it may be evaluated within the framework of natural resource assessments. Basic concepts of production are presented in the beginning sections in order to provide a common-ground basis for examining the ecological analysis of forage production. Factors that increase the difficulty or complexity of determining production are also discussed, in addition to the use of models to predict forage production.

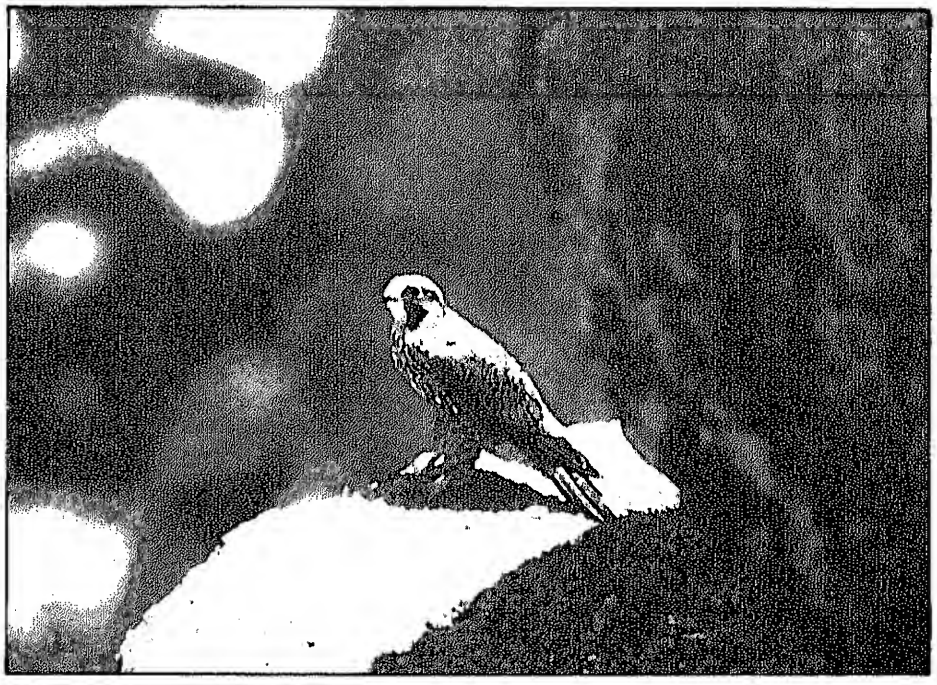
Request *Analysis of Forage Production for Assessments and Appraisals*, General Technical Report RM-96, by John E. Mitchell.

The second of the five papers, *Analysis of multiresource Production for National Assessments and Appraisals*, is an overview of the analytical methods that have been used in integrated (multidisciplinary, multiresource, and multilevel) land management production analyses. The ecological and economic theory underlying both simulation and optimization methods are reviewed.

assessments. The paper covers three main themes: (1) a presentation of the state-of-the-art methods available for estimating numbers in wildlife populations; (2) a contrast of the methods available for estimating animal population numbers with the methods actually being employed; and (3) an assessment of the role of the methods for estimating populations, and the role of the available data generated by these methods in national assessments of wildlife and fish.

The review also examines the advantages and disadvantages of numerous estimating techniques, including complete enumeration, classical sampling methods, line and point methods, spatial distribution methods, indexes, capture-recapture methods, removal methods, catch-effort methods, change-in-ratio method, and the bounded count method.

Request General Technical Report RM-99, by Stephen A. Miller.



The third report discusses the ecological analysis techniques for estimating wildlife and fish resources. It provides land managers involved in various aspects of assessing wildlife and fish resources with a better understanding of the techniques available to predict population occurrence, quantities, harvest quantities, and structures.

Techniques are included that have relevance to and applicability for the production of a renewable natural resource assessment model or models of the Nation's forests, rangelands, agricultural lands, and associated waters.

Also covered are chapters on resource outputs compared with ecosystem components; characteristics and criteria needed for evaluation; description and evaluation of ecological analysis techniques; and research and development needs.

Request *Prediction of Wildlife and Fish Resources for National Assessments and Appraisals*, General Technical Report RM-98, by Clifford L. Hawkes, David E. Chalk, Thomas W. Hoekstra, and Curtis H. Flather.

The last paper in the series, titled *Aggregate Timber Supply for National Assessments and Appraisals*, is an overview of major analytical techniques for aggregate timber supply analysis for different broad geographical areas. It is intended primarily as a reference document for analysts concerned with state, regional and national natural resource supply projections. The report emphasizes techniques for analyzing long-run trends in stumpage supply and opportunities to alter or manage those resource supply trends.

The paper discusses land allocation, timber growth and yield, short-term harvest flows, and long-term timber investment modeling components. Representative techniques of major analytical components are summarized in tabular form for different regions. Aspects of uncertainty in timber supply analyses are also discussed.

Request General Technical Report RM-100, by Ralph J. Alig, Bernard J. Lewis, and Paul A. Morris.

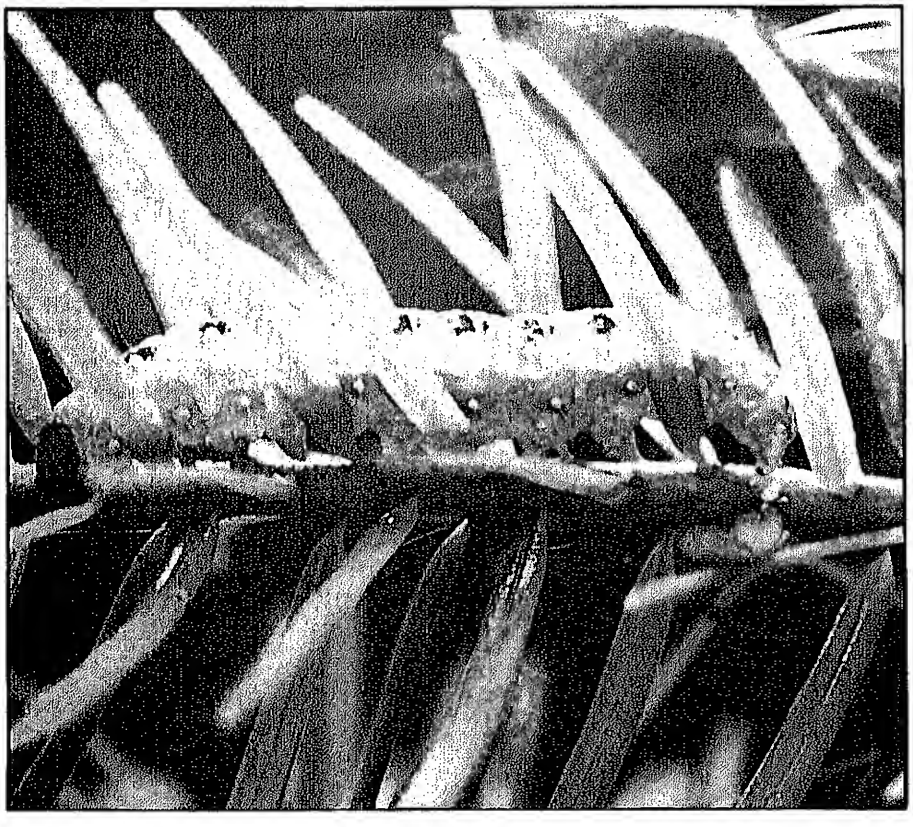
Scientists attack the western spruce budworm problem

by Samuel T. Frear
Pacific Northwest Station

The spruce budworm is one of the most destructive insect pests in western forests, and at times the problem seems as big as the West itself. The vastness of scale and diversity of geography and climate engenders diversity in the budworm, and this in turn has greatly complicated the research task.

Throughout much of the West, such as in the Blue Mountains of Oregon, the population of budworms and the damage they do has fluctuated considerably over the years. But the pest has been a chronic problem in some areas, such as the Douglas-fir and true fir stands of Montana and Idaho.

This budworm larvae is soon to be at the peak of its feeding stage.



Each area of the West has its own history of outbreaks and local events are often seen by residents as isolated events. Outbreaks, however, have occurred in every western state except California during the past 60 years, and the resulting defoliation provides a common thread linking these geographically disparate areas—tree foliage damaged by the insect turns red, presaging important economic and environmental effects.

Efforts to learn about the budworm and how to moderate its impact on western forests are coordinated by the Canada/United States Spruce Budworms Program—West (CANUSA-West), headquartered in Portland, Oregon at the Pacific Northwest Station. The United States and Canada agreed in 1977 to cooperate in the accelerated program. The following year, the program began with CANUSA-West as one of two components of the international effort. The program now is in the 5th year of a 6-year charter. Building on 30 years of studies by Federal, State, and local agencies and institutions, it is an accelerated research and development program with a goal of developing an integrated pest management approach to solving the problem.

The program includes almost 100 investigators from 12 universities, the Pacific Forest Research Centre of the Canadian Forestry Service, the British Columbia Forest Service, four Forest Service Experiment Stations, and four Forest Service Regions. Twenty distinct disciplines are involved. There are also cooperators from private industry, provincial, and State forestry agencies.

Their research is concentrated in six target areas: budworm population and damage evaluation, stand dynamics, economic impacts, treatment strategies, environmental impacts, and pest/resource management systems. This last target is the heart and soul of CANUSA-West: to package all the research findings in a practical, usable form to assist land managers in making decisions about the western spruce budworm.

Spruce budworms are ubiquitous in North America, but the insect in the West is taxonomically distinct and behaves differently from its eastern cousin. The coniferous forests of the West are very different from the rather uniform forests in eastern North America. The topography in the West is highly varied, with rolling slopes, steep-sided valleys, and heavily glaciated mountain areas separated from one another by great distances involving prairies, ranges, and desert that stretch from horizon to horizon.

The climate varies from the rainfall belt west of the Cascade Range in Oregon and Washington to relatively dry, continental conditions with long winters and moderate precipitation. Soils vary in depth and parent material. The tree species are not uniform in crown position or age. The major host species vary, and may be climax or seral depending on the climate, geographic location, soil type, and elevation.

Finding management controls for infestation of spruce budworm is complicated in the West not only by diversity of geography and climate, and variation in the insects, but also by the wide variety of tree species that act as its host. It prefers to feed on the true firs (*Abies grandis, A. lasiocarpa, A. concolor),* and Douglas-fir (*Pseudotsuga menziesii*); less so on Engelmann spruce (*Picea engelmannl*), and western larch (*Larix occidentalis*).

There was an assumption for many years that the insect in the West was the same as in the East, but scientists in the West have agreed for more than 10 years that they are dealing with a different budworm. The major species of budworm in the West, *Choristoneura occidentalis*, is difficult to tell from other species, and there is a range of variation within the species.

Analysis of larvae from populations throughout the West has shown considerable variation, suggesting the existence of definite races. These could possess different behavioral characteristics sometimes noted from other research. For example, insect populations from various locations are not all susceptible to insecticides.

Budworms infest more than 5 million forest acres in western Canada and the western United States annually. Unlike its eastern relatives, however, the western budworm usually does not kill trees. Only about 1 percent die from an attack, and these are usually overstory or understory trees that suffer unusually heavy defoliation. The major damage is the loss of height and radial growth in trees, caused when the budworm consumes the new foliage.

The growth loss is significant for long-term forest management, causing a decline in future harvest levels in many areas.

Budworm population and damage evaluation

One of the major research efforts in the West is to document an outbreak's real effects. Until 10 years ago, a basic assumption in the West was that the budworm caused the same damage that it was causing in the East. When CANUSA-West began operations in 1978, the information base was very weak. For that reason, about 25 percent of the CANUSA-West budget is being used to assess budworm populations and to measure their impact—to study the effect budworms actually have on forest foliage.

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Again and again, questions about the western budworm have been answered, "We don't know." R.W. Stark, program manager of CANUSA-West, stressed that research started at ground zero in 1978. Scientists now know there is a wide variation in how the insect infests different tree species. The size of a tree makes a difference, as does the mixture of species, and the degree of infestation. Other local factors can be the steepness of slopes and the relationship of cutting units to surrounding timber. In addition, impacts vary from one geographical area of the West to another.

Research on population dynamics is providing insight into why populations change over time and differ from place to place. This kind of research requires many years of data collection and analysis, usually within the same locations. Ideally, the same type of information should be collected from several geographical areas and should represent different forest species, species composition, topography, and weather.

Stand dynamics

A major accomplishment, after 5 years of the program, is the development of a computer-based simulation model of budworm population dynamics, including natural enemies, stand foliage, and climatic considerations.

The challenge in determining stand dynamics is this: If you know budworms will consume a certain amount of foliage, what will this do to tree growth, mortality, and regeneration? This type of information will be included in a stand prognosis model that will predict the effects—in measurable quantities—that a certain budworm population will have on a tree, a stand, or a forest; the growth of young stands; forest fires; watershed quality; wildlife habitat; and opportunities for recreation.

Information is being obtained on the effects of top kill, the loss of growth, the deformation of a tree. Data already show a loss of seed production as one of the more subtle effects, Stark said.

He explained that an assumption prevailing in the Program is that proper forest management may discourage outbreaks. There is a major effort, therefore, to seek causal effects and develop silvicultural and management guidelines to prevent outbreaks from occurring. Since insects are a normal part of the forest with outbreaks an aberration of this relationship, scientists are trying to understand the environmental conditions that keep budworms from getting to the outbreak stage.

Economic impacts

Forest managers have told researchers that it is important for them to have specific information about the budworm's impact on timber yield in terms of timing of losses in merchantable timber. It is also important for them to know the impact on yields from harvested volume throughout a planning period, whether this is expressed as volume changes or in present net worth.

The adult moth of the spruce budworm is at the dispersal stage, spreading out to infest new areas.

So far researchers have introduced yield changes for various scenarios using computer-generated harvest schedules. These schedules have been run to determine if the impacts would appear to forest managers as changes in harvest volume or as infeasible plans. The cost and losses for each scenario were calculated as differences in total net worth between plans impacted and not impacted by the budworm. Work in the future includes using assessing budworm-caused changes in merchantable volume rather than simply changes in total yield table volumes.

Progress is being made, and with better estimates of the impact of the budworm on yield or volume, researchers will be able to accurately assess the overall impacts in terms of dollar or timber production lost.

Rearing spruce budworms in a laboratory is necessary to test the effects of chemical and biological controls.

Treatment strategies

Scientists believe it is possible to use silvicultural techniques to reduce the impact of the western spruce budworm on the establishment and growth of conifer stands. They have found positive results in using these methods to limit the spread of the budworm. If silvicultural actions are used over large enough areas, they may influence dispersal of adult and larval budworms, help limit population size, and significantly reduce the impact on stands managed for production of wood fiber.

Some of the silvicultural techniques that appear to be valid include such measures as adjusting ratios of host to nonhost tree species, creating buffers, mixing species of planting stock, and increasing the size of cutting areas if possible.

Several studies are underway to test silvicultural prescriptions. Plots have been established in New Mexico to demonstrate the effect of four harvesting systems on the growth and yield of remaining trees and on the budworm population. Data collection on 48 young Douglas-fir and 20 subalpine fir stands is also underway to evaluate the influence of various silvicultural recommendations for reducing budworm impact in young stands.

Another natural approach to control budworm attacks is the use of pheromones—chemical imitations of the insect's sex attractant. So far the use of these has not disrupted the mating cycle of the budworm. The technique, however, does have promise as a survey tool, attracting moths to sampling traps.

Biological control methods are other treatment strategies being studied by CANUSA-West. Several viruses have been tested, and they can be produced. "Biological control, however, needs much more work," Stark said. A problem frequently encountered among managers, he believes, is the notion which stems from agricultural experience that 100 percent control of the insect is needed. Foresters are not satisfied with 50 or 60 percent control.

Forestry, however, has the luxury of time and space. Such intensive short-term control may not be needed, Stark believes.

There are natural enemies of the budworm, and researchers are working on developing forest management techniques to encourage them, as part of a natural approach to control the insect. Entomologists Torolf Torgersen and Robert Campbell of the Pacific Northwest Station have found that birds and ants are extremely effective as predators when budworms are at relatively low densities. These researchers are measuring the sometimes dramatic effects of these two

predators and how they relate to outbreaks or the lack of outbreaks. Silvicultural techniques are sought to encourage the colonization of birds and ants in forests normally suceptible to the budworm.

Environmental impacts

The environmental acceptability of various spruce budworm management strategies is essential information that will be included in a decision support system for forest managers. Information will be provided on the fate of insecticides in the forest and their impacts on aquatic and terrestrial ecosystems, as well as the environmental impacts of other management strategies.

CANUSA-West is not placing heavy emphasis on the study of insecticides to control budworm populations. Although this is an essential tool for managers, Stark said that there is a reluctance among researchers in the West to rely unduly on chemicals to combat the budworm. "We subscribe to the principles of integrated pest management which include the utilization of natural controls to ameliorate the conditions which cause outbreaks," he said. There is increasing public concern in the West about the use of insecticides, but there is a practicality in the ecological approach as well. Spraying is difficult and costly in the West because of rugged topography and complicated land use and ownership patterns.

Stark says the budworm is a natural problem. "The wonder is," he commented, "that of the thousands of insects in a forest, only a few cause problems." Even outbreaks are natural, he emphasized, when viewed in the long perspective of time. The trees of the West provide this perspective; in their long lives they may survive one or more outbreaks.

Pest and resource management systems

As many as 300 studies will be made for CANUSA-West by 1984, providing data on budworm populations, damage evaluation, stand dynamics, stand prognosis, economic impacts, chemical and microbial insecticides, sustained biotic controls, suppression strategies, and pest management systems.

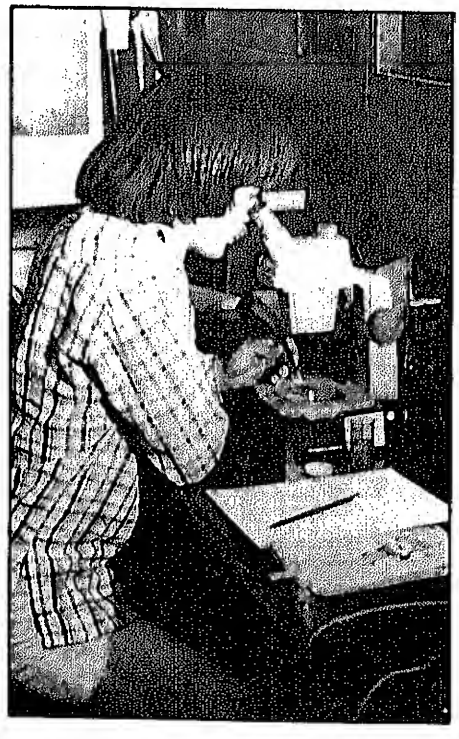
A technology transfer working group, composed of representatives from industry, National Forests, and other agencies, concluded that the most effective information base at the end of the program CANUSA-West will be a three-volume user's manual. These documents will summarize the basic entomological and host tree research effects on and guidelines for protection of individual trees and stands, and the implications of the budworm on a forest and regional basis for forest planning and policy.

Results of CANUSA-West's research efforts will be integrated into a decision support system that will assist managers and planners in making decisions about forest resources that may be affected by budworm outbreaks. A key component of this decision support system is a series of computer simulation models that predict the effects of budworm outbreaks on forest stands. A budworm population model being developed will simulate budworm dynamics, including development, feeding, dispersal, and mortality. This model will be linked to another that predicts stand growth and yield (the stand prognosis model) to simulate the effects of defoliation by budworm on yields.

A wide-range of short-term and long-term treatments (from direct suppression to silvicultural manipulation) can then be simulated to predict their effects on both budworm populations and stand yields. The combined prognosis-budworm model will allow evaluation of many alternative strategies for a range of initial stand conditions. Models that use stand yield data to optimize management of forest resources may also be used to evaluate treatment option and their effects on long-term management and planning activities.

Thus it is that the computer, often an integral part of a forester's tool box, will be incorporated even more into the day-to-day management of a forest. Stark believes that the Program will produce meaningful and accurate information that will be readily accessible to forest managers. Sitting at a terminal keyboard, they will be able to use the computer models to arrive at decisions to be incorporated into an integrated forest management plan.

Examination of the stomach contents of birds confirmed their importance as predators of the budworm.



Estimating road construction costs quickly and accurately

by Delpha Noble
Intermountain Station

Most forest land management activities, including timber harvesting, surface mining, and recreation, require ground transportation systems, which means that forest roads must be designed and constructed. The present National Forest road system includes 300,000 miles of designed roads, and planners say 100,000 additional miles of roads will be needed in the future. Approximately 10,000 miles of roads are constructed or reconstructed each year.

Forest engineers charged with building and maintaining this vast system of roads consider a variety of factors other than access for the various resource activities. One of their major concerns is whether the road design will be compatible with requirements to protect water quality. To meet this concern, two important questions must be answered: How much will it cost if specific erosion control treatments are used, and will that estimated cost be accurate.

Currently, engineers use estimating guides to calculate the cost of a proposed forest road. This process uses tabular values and repetitive hand calculations that are time-consuming, tedious, and prone to error. In addition, current cost estimation guides do not contain information on erosion control techniques; until now, many installation costs were not well defined.

Researchers at the Intermountain Station and the University of Idaho have developed speedy and accurate cost estimation methods for forest road construction, including erosion control techniques, that can be used with minicomputers or programmable calculators. The procedures were developed by Edward R. Burroughs, Jr., Intermountain Station project leader for engineering research; and Donald F. Haber, Department of Civil Engineering at the University.

Cost studies

To develop the system, Haber and Burroughs conducted cost studies of road construction in the Silver Creek Experimental Watershed of the Boise National Forest, Idaho. Silver Creek, in the heart of the Idaho batholith, is one of the most difficult places to harvest timber, and to build roads, in the West. The scientists obtained information on crew composition and production rates for a variety of standard construction activities, including clearing and grubbing, excavation, and road surfacing. They also monitored installation costs for specific erosion control treatments such as seeding, fertilizing, and mulching.

Procedures to estimate installation costs of these erosion control measures are available to the Northern and Intermountain Regions as "stand-alone" programs or as supplements to standard guidelines now being used. Each program is interactive, that is, the program prompts the user for specific data on acres, volumes, or linear feet. If a program requires specific data on equipment or labor (current unit rates are given for those items), the user can change those rates before calculations begin. For the erosion control programs, the computer/ calculator performs the computations, displays the necessary crew composition, estimated hours for

the job, and complete cost information. Checks are built into the programs to eliminate errors caused by obviously incorrect data; e.g., sums of percentages not totalling 100. For the other estimating programs, the computer/calculator performs the computations, prints out incremental costs, then prints complete cost summaries.

Engineers in the two Regions are enthusiastic about the new system. Ted Zealley, responsible for transportation preconstruction in the Northern Region, says, "The system is excellent—primarily it saves time in making the estimates as well as in checking. The computer encourages the designer-estimator to break the project down into smaller segments and avoid making an overall gross average for a project. In addition, the estimator can easily identify incremental costs for various design alternatives."

Zealley's sentiments are echoed by Jim Trenholm, in charge of transportation system design and construction for the Intermountain Region. He says, "We will be using the system—there's no doubt about it. It's a real time-saver, and very accurate."

Using the interactive computer system at the University of Idaho, Haber developed the programs for the two Regions' cost estimating guides. These BASIC programs were then converted for interactive use on the TI-990 desktop minicomputer, frequently used in the Northern Region. The minicomputer, if available, is probably the most efficient method for cost estimating. It is fast, flexible, and it can store large programs and a great amount of data.

An alternative

Recent advances in programmable calculator technology provides an alternative to the minicomputer. Burroughs has adapted each of the cost estimating programs to the Hewlett-Packard HP-41CV calculator. He says the use of this equipment with cassette drive is the most practical system for the average user, considering its relatively modest price. The equipment required is:

-HP-41CV calculator with Extended Functions Module and Extended Memory
-Digital Cassette Drive
-HP-IL Interface Module
-Thermal Printer/Plotter

The use of a magnetic card reader allows the user to add new programs to the cassette tape by (1) reading the new program into the calculator from magnetic cards; then (2) transferring this program to the cassette tape.

The new programs have also been developed for use with the HP-41CV calculator using a card reader. This system requires an HP-41CV programmable calculator with an Extended Functions Module, two Extended Memory Modules, a card reader, and a Thermal Printer/Plotter. Each program must be read into the calculator from magnetic cards. While this process is slightly slower than the cassette drive system, it provides the same interactive data input and printed output as the cassette tape system.

Advantages

The researchers cite several advantages of their computer/calculator-aided procedures:

- Savings in time and money.
- Interactive programming prompts the user to provide necessary data, minimizing the chance for omissions and computational errors.
- The programs provide a hard copy of the procedure for future reference.
- Checking is simplified; only the input values need to be verified.
- Engineers can quickly determine costs of slash disposal and excavation alternatives to evaluate cost differences.
- The programs can be updated easily as new information becomes available on new construction equipment and/or erosion control techniques.
- Users can quickly change current unit costs in the programs to reflect local conditions or general economic trends.
- The programs can be used with: (a) desktop minicomputers using BASIC language tapes; (b) handheld calculators with cassette tape drives; or (c) handheld calculators with magnetic cards.

Arrangements have been made to hold workshops to orient preconstruction engineers in the use of computer/calculator-aided cost estimation techniques. A detailed user guide will be provided for each cassette tape and set of magnetic cards. Information on the availability of these programs and the user guide may be obtained from:

Dr. Edward R. Burroughs, Jr.
Forestry Sciences Laboratory
Montana State University
Bozeman, Montana 59717

Chaparral R & D program...catalyst for action

by John K. McDonald
Pacific Southwest Station

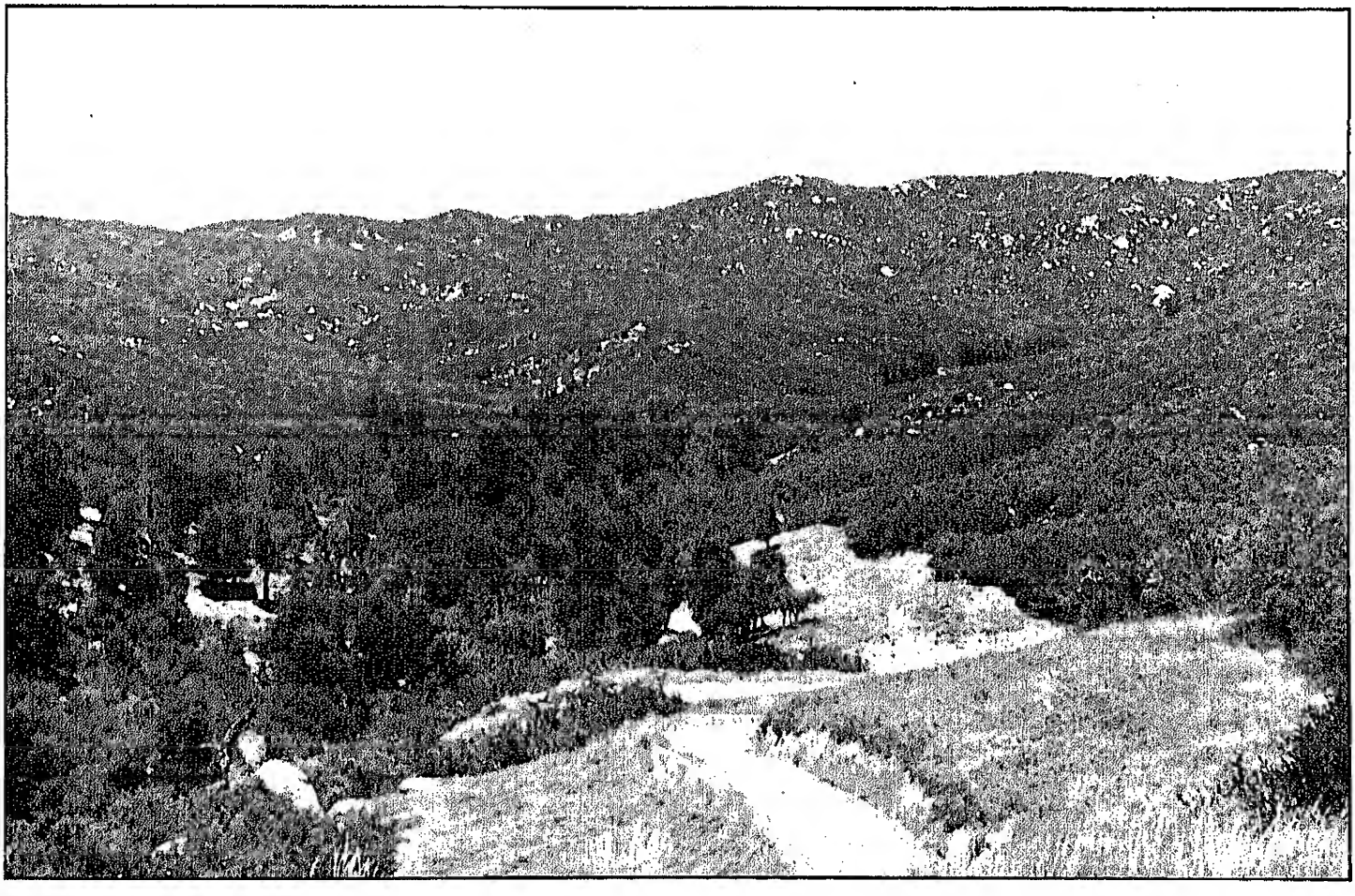
Readers of *Forestry Research West* were first introduced to the Pacific Southwest Station's Research and Development Program on Chaparral Management in 1978, just about a year after the 5-year program began to function.

The October 1978 issue of *Forestry Research West* featured an article entitled "Developing Alternatives for California's Chaparral" that highlighted on-going research and outlined objectives of the Program to test and demonstrate the information produced by researchers, and to encourage the implementation of their findings by managers of the more than 20 million acres of chaparral lands in southern California.

Now that the Program has been officially concluded (September 1982), it is appropriate to review the history of its establishment, highlight its accomplishments, and determine whether the management alternatives it proposed are being considered or implemented by resource agencies.

Historic perspective

The chaparral ecosystem in California comprises more than 20 million acres, from 20 to 30 percent of the State's total land area. In southern California, some 13 million people live in or near chaparral-covered hills and mountains, or in the foothill valleys below.



Chaparral—evergreen, sclerophyllus shrubs —and associated vegetation types—cover much of the wildlands of central and southern California above 500 feet elevation.

Chaparral ecosystems in California are characterized by dense stands of tough shrubby vegetation made up of highly flammable species such as manzanita, ceanothus, and chamise. These species are of the same botanical group as the maquis of the Mediterranean Rim countries and the brushfields of Australia, South Africa, and Chile. The ecosystems in these regions are dominated by Mediterranean-type climates, with summer drought, maritime air influences, strong winds, and precipitation concentrated in the mild winter months.

For decades, management of California's chaparral was concentrated on watershed protection and protection from fire, particularly for the urban areas that were so rapidly encroaching into or adjacent to the hills and mountains. Management of the vegetation was oversimplified because the vegetation was seen as, more or less, worthless.

In the 1960's and early 1970's, land managers began to develop an increasing awareness of the diversity of the chaparral lands and their potential for recreation, aesthetic values, improved grazing, and protection and habitat for hundreds of species of native wildlife. This
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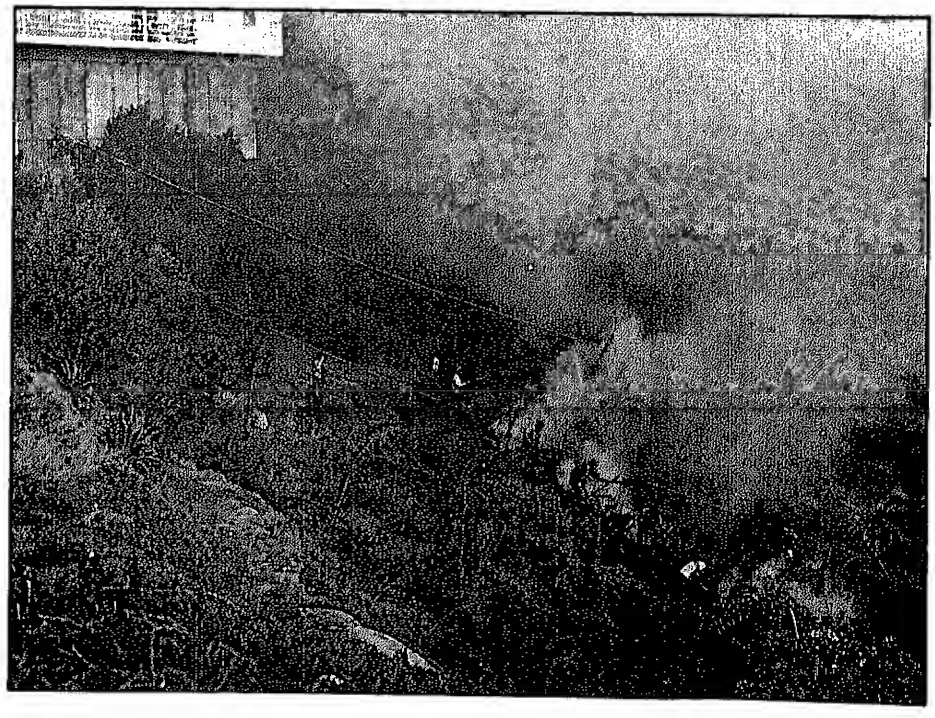
At the same time, there was a growing realization that, while fire prevention programs and suppression of low and moderate density wildfires reduced the frequency and size of wildfires, the alteration of natural fire regimes frequently resulted in tremendous buildup of vegetation to fuel catastrophic fires. This realization led to plans for increased use of prescribed burning to manage chaparral fuels and provide positive resource benefits.

It was in response to these more comprehensive management needs that the Chaparral Research and Development Program was established as an intensive 5-year effort to develop, test, and demonstrate a wide range of options for maintaining or increasing the productivity of chaparral and its related ecosystems.

Staffing

After several months of planning to develop the charter and objectives of the Program, and to select the research problems of a multidisciplinary Research Work Unit assigned to it, the R&D Program began its work in February 1977. It was headquartered at the Forest Fire laboratory, Riverside, California, and was administered by the Pacific Southwest Station in cooperation with the Pacific Southwest Region (R-5) of the National Forest System.

The Program staff was brought in from the National Forest System to provide linkage between researchers and practitioners. Jimmie L. Hickman, who was program manager from 1977 to 1980, came from the Sequoia National Forest. Hickman was succeeded by George A. Roby, also from the San Bernardino National Forest. William A. Dean, assistant program manager, came from the Sierra National Forest. Lisle R. Green, PSW range scientist and a recognized expert in fuels management and prescribed burning, was assigned fulltime to the Program staff.



C. Eugene Conrad, PSW research botanist, was named project leader of the Research Work Unit. At the peak of the Program, the research team (Research Work Unit 1652—Management of Chaparral and Related Ecosystems) consisted of 11 fulltime professionals, with a supporting staff that ranged from 8 to 11 technicians and clerical personnel. The scientific staff included research botanists, microbiologists, range scientists, ecologists, plant pathologists and physiologists, hydrologists, soil scientists, and research foresters.

In addition to the studies conducted by the PSW research team, a broad spectrum of extramural research was conducted through cooperative agreements with nine colleges and universities. Cooperative agreements also involved professionals from Los Angeles County, the National Park Service, the California Department of Forestry, and the California Department of Fish and Game.

Needs assessment

Top priority of the Program within its first few weeks was to develop a needs assessment to refine the selected research problem areas. The needs assessment was outlined in workshops that brought together researchers and practitioners from the Forest Service and from some 25 to 30 cooperating Federal, State, and county agencies, universities and colleges, and resource-oriented industries.

In keeping with Forest Service charters for R&D Programs, it was planned that the scientists would draw on previous research by the PSW Station and elsewhere, and that the Program's research would be limited to efforts to supplement current knowledge to fill gaps in certain problem areas and to provide information that would lend itself to solving problems selected during the needs assessment. The intent was to identify, develop, and integrate research results that could be put to use by land managers within the life of the Program.

Dynamics and management

The 10 research problems selected can be roughly grouped into two broad areas, categorized by the intent or objectives of the R&D efforts. The first involved research aimed at gaining a better understanding of the dynamics of chaparral and its associated ecosystems, through studies of vegetation classification systems; the effects of fire on hydrology and soil movement, hydrophobic soils, and nutrient cycling; the physiology of chaparral species; and the effects of photooxidants on chaparral vegetation and on air and water quality.

The second involved development of guidelines for use of prescribed burning and other fuels management techniques to reduce the number and severity of large fires, for management of wildlife habitat, woodlands, and riparian zones, and management techniques for the protection of homes and other structures in the wildland/urban interface.

New findings or applications

The research Unit, and its cooperators, either through new findings or through interpretive applications of existing information contributed significantly to a better understanding of chaparral ecosystems in each of the problem areas.

•A new vegetation classification system developed by the unit is now being used throughout southern California and is being adapted for Statewide use by several agencies. It has also been adopted as the framework for resource inventories by the State of Hawaii. The new system is described in *A Vegetation Classification System Applied to Southern California,* General Technical Report PSW-45, by Timothy E. Paysen, Jeanine A. Derby, Hugh Black, Jr., Vernon C. Bleich, and John W. Mincks. Supplementary user guidebooks and conceptual reports are in press or in process.

•New findings were reported on the amount of nitrogen lost during and after a fire, and recovery mechanisms were identified and documented. The interrelationships among soil microbes, heating rates, and soil moisture, and the role of microorganisms and nitrogen fixation by nonlegumes have been reported (see reports by DeBano, Dunn, Conrad, Poth, and Riggan in General Technical Report PSW-58).

•Research on hydrophobic or nonwettable soils was a continuation of previous research at PSW. New findings on the role of hard-to-wet soil layers in erosion processes were incorporated in hydrologic studies to identify how relationships between fire, hydrophobic soils, changes in soil texture, and erosion can be predicted. *Water Repellent Soils: A State-of-the-Art,* by Leonard F. DeBano, was issued as General Technical Report PSW-46 in 1981, and other reports are included in General Technical Report PSW-58.

•A comprehensive descriptive model on sediment transport on southern California watersheds from ridge top to the Pacific beaches was developed under cooperative agreement with the California Institute of Technology. A series of reports—EQL Report Nos. 17-A through 17-D—have been issued or are in press by the Environmental Quality Laboratory, California Institute of Technology, Pasadena.

•Research on chaparral physiology produced new information on photosynthesis and carbon metabolism, growth regulators, and biomass production (see papers by Plumb, Hastings, Lawrence, and Oechel in General Technical Report PSW-58).

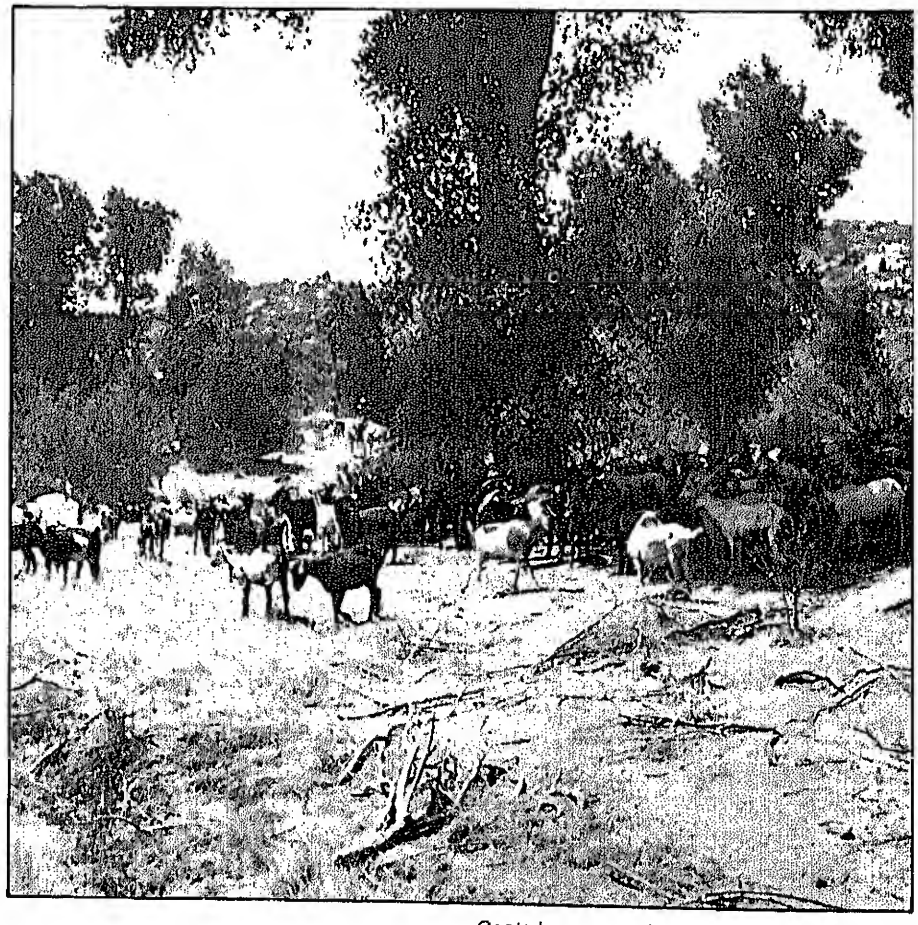
•Research on the effects of photooxidants on chaparral vegetation and on air and water quality were reported in numerous technical journals and in the *Proceedings of Symposium on Effects of Air Pollutants on Mediterranean and Temperate Forest Ecosystems,* General Technical Report PSW-43, issued in 1980. More recent research has identified emissions of nitrogen oxides as a major source of acid rain and nitrate water pollution in the watersheds of the Angeles National Forest. The research has identified for the first time close relationships between rate of stream discharge and water quality, and it has traced regional trends in nitrate water pollution. (This research will continue under a recent grant by the UNESCO Man and the Biosphere Program.)

•Wildlife research was conducted under cooperative agreement with California State Polytechnic University, and with Pomona College. The research was related to the effects of fire on birds, small mammals, reptiles, and insects within the chaparral ecosystem (see the paper by Force and Wirtz in General Technical Report PSW-58).

•Research and demonstrations in prescribed burning resulted in a comprehensive publication entitled *Burning by Prescription in Chaparral,* by Lisle R. Green which was published in 1981 as General Technical Report PSW-51, and the demonstrations on biological control were reported in *Using Goats to Control Brush Regrowth on Fuelbreaks,* by Lisle R. Green and Leonard A. Newell, in General Technical Report PSW-59.

•The problem area of riparian zone management and upslope treatments involved research on hardwoods, especially the oaks, and on mechanical, biological, and chemical treatments. The *Proceedings of the Symposium on the Ecology, Management, and Utilization of California Oaks,* issued in 1980 as General Technical Report PSW-44, covers much of the research and development in this area. The major experiments and demonstration on biological control of vegetation are summarized in General Technical Report PSW-59.

•Cooperative agreements with Los Angeles County Forestry Department produced guides for homeowners that outlined techniques for landscaping, vegetation maintenance, soil stabilization, and other measures for protecting residences in the wildland/urban interface from the onslaught of the fire-flood cycle. A preliminary booklet *A Homeowner's Guide to Fire and Watershed Management at the Chaparral/Urban Interface,* which was widely distributed by Los Angeles County and various homeowner's associations, will be followed by a more comprehensive PSW General Technical Report being processed for publication.



Goats have proved to be an effective biological means of controlling brush regrowth in chaparral and associated ecosystems.

Technology transfer

From its inception, the Program concentrated on ways to translate research findings into practical programs that could be transmitted quickly to resource managers. Current and past research findings were interpreted and integrated with management experiences into formats that managers and landowners could use to formulate their own chaparral management policies and objectives.

The Laguna-Morena Demonstration Area, a 130,000-acre site in San Diego County, was used to test and display the use of mechanical, chemical, and biological control treatments on vegetation, and the use of prescribed fires to reduce fuel hazard, improve grazing, and enhance wildlife habitat.

Before formal publications were completed, informal but comprehensive "user guides" were distributed to cooperators, land owners, managers, and practitioners. The guides covered such topics as measuring moisture content in living chaparral, vegetation classification, burning prescriptions, use of goats for brush control, water-repellent soils, wildlife-habitat relationships, and protecting residences in the fire-prone chaparral/urban interface.

Training sessions and technical workshops were held on many of these same topics, and CHAPS Newsletter was distributed periodically to update practitioners. The audience for the newsletter grew from an initial 90 to almost 600 during the 5-year period.

Symposia

The Program cosponsored four major symposia:

- International Symposium on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems, August 1-5, 1977, Palo Alto, California
- Ecology, Management and Utilization of California Oaks, June 26-28, 1979, Claremont, California
- Effects of Air Pollutants on Mediterranean and Temperate Forest Ecosystems, June 22-27, 1980, Riverside, California
- Dynamics and Management of Mediterranean-Type Ecosystems: An International Symposium, June 22-26, 1981, San Diego, California

The symposia attracted audiences of resource managers, scientists, and concerned citizens that ranged from 250 participants at the symposium on California oaks, to almost 600 at the international symposium on dynamics and management of Mediterranean-type ecosystems.

Demand for the proceedings of the four symposia was so great that initial printings of several thousand copies of each were distributed on request in record time. The publications are now virtually out of print, but they are available at U.S. Government Depository Libraries and through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia.

Catalyst for change

On its record of research contributions and its efforts to demonstrate alternative methods of managing chaparral lands to increase or enhance productivity, the Chaparral Research and Development Program was successful. In part, that success is attributed to its establishment at a time when interest in chaparral management was high and the need for information was great.

The management philosophies of agencies, groups, and individuals responsible for or concerned about chaparral lands have changed significantly during the past 5 years. Although we certainly cannot say that the Program was solely responsible for these changes—it was, in fact, established during a period when there was a widely recognized need for change—we can safely say that the Program significantly influenced the changes.

In 1977, agencies such as the California Department of Parks and Recreation, the California Department of Water Resources, the U.S. Bureau of Land Management, and the U.S. Bureau of Indian Affairs either had no active programs or only small-scale programs on intensive management of all chaparral resources, and particularly on prescribed burning.

By 1982, the California Department of Parks and Recreation had a full-scale program to train personnel in prescribed burning in several State parks. The Department of Water Resources is attempting to augment water supplies through chaparral management on several reservoirs. The U.S. Bureau of Indian Affairs is now working with the California Department of Forestry on possible use of the new CDF Chaparral Management Program on BIA lands within the State.

The Forest Service itself was overly cautious about the use of prescribed fire in brushlands in 1977, but prescribed fire is now a widely and safely used tool in fuel-treatment programs. Region 5 has established a Chaparral Management Program that will take a more interdisciplinary approach to chaparral management and will provide for management of chaparral lands for multiple resource values.

In 1977, the California Department of Forestry was on record against the use of prescribed fire in most areas of southern California. In 1981, it established a new Chaparral Management Program that is funded from the State's Energy Resources Fund (ERF) under the Investing for Property Program. The program involves State cost sharing for conducting prescribed burns on private lands for fire-hazard reduction, watershed management, and range and wildlife habitat improvement.

In the first year of the program, the Department and cooperating agencies successfully burned 57,000 acres. Plans call for burning about 80,000 acres a year, statewide. The emphasis will be in areas where high brush volume represents danger to homes and communities, and to produce optimal yields of water, forage, and wildlife habitat.

The State projects a cost/benefit ratio of 4.45 to 1 in benefits through improved property protection,water yield, wildlife habitat improvement and forage yield over a 5-year period. For whatever share it can claim in influencing the development of new programs of chaparral management throughout the State by agencies, groups, and individual landowners, it appears that the Chaparral R&D Programs role as a "catalyst for action" had an equally effective cost/benefit ratio.

Acknowledgment: This article is a synthesis of administrative reports and publications prepared by former Program Managers Jimmie L. Hickman and George R. Roby, Project Leader Gene Conrad, former PSW Research Forester Serena Hunter, and former PSW Information Specialist Marcia A. Wood.

New publications

Solving the problems of calibration

If you're in the business of measuring the water potential of soils, plant tissues, and other media in the laboratory and the field, you probably use a thermocouple psychrometer. And you probably find that calibration, one of the most important steps in using thermocouple psychrometers, can be a headache. Some of the problems are (1) the logistics of calibrating large numbers of psychrometers; (2) applying isothermal calibration data to unstable thermal environments; and (3) projecting limited calibration data to extended ranges of temperature and water potential.

Two Intermountain Station scientists have developed a mathematical model that should alleviate these problems and enhance accuracy. Ray W. Brown, plant physiologist, and Dale Bartos, range scientist, discuss their model in *A Calibration Model for Screen-caged Peltier Thermocouple Psychrometers*, Research Paper INT-293-FR-32. The model applies to a water potential range of 0 to −80 bars, over a temperature range of 0° to 40° C, and for cooling times of 15 to 60 seconds. In addition, it corrects for the effects of temperature gradients over zero-offsets from −60 to +60 microvolts.

The authors discuss the development of the model, together with the theory of thermocouple psychrometers and techniques of calibration and cleaning. The publication also includes information for computer programing and tabular summaries of model characteristics. Copies of the report are available from the Intermountain Station.

Controlling the ponderosa pine needle miner

A new report from the Rocky Mountain Station discusses the use of foliar sprays and systemic insecticide implants to control needle miners in ponderosa pine.

Scientists conducted three separate studies on trees near Boulder, Colorado. Seven months after treatment, implant-treated trees averaged 3.2 percent needles per branch infested with living larvae, compared to 28.0 percent for untreated check trees. Foliar sprays resulted in 0 percent and 0.2 percent needles infested for permethrin and acephate, respectively, versus 5.7 percent in check trees. The timing of treatments is critical to prevent invasion of foliage by young larvae.

To learn more, request *Implants and Sprays for Control of Ponderosa Pine Needle Miner in Foliage of Individual Trees*, Research Note RM-420, by Robert E. Stevens and David A. Leatherman.

Estimating the potential for restoring coal-mined lands

One of the most widespread environmental concerns in the Interior West is the adverse effect of spoils left in the wake of surface mining for coal. Land managers with reclamation responsibilities require criteria and guides that predict revegetation potentials on the various kinds of surface-mined lands. Equally important is the need to identify and prescribe revegetation measures, as well as management policies for such land.

A recent Intermountain Station report presents results of a cooperative study conducted to provide information to help decisionmakers resolve some of these mining-environmental concerns.

Models to Estimate Revegetation of Land Surface Mined for Coal in the West, General Technical Report INT-123-FR-32, provides a strong conceptual framework for evaluating the success of proposed vegetative rehabilitation efforts on areas to be surface mined. It includes site-specific maps to provide soil, precipitation, growing season, and vegetation type information, critical to the evaluation system. To produce this and other information, researchers surveyed the results of most coal surface-mine rehabilitation efforts in the West through 1976.

The report is the final product from work funded by the Forest Service, the Environmental Protection Agency, and the Fish and Wildlife Service. Authors are Paul E. Packer, retired, former project leader of the Intermountain Station's mine spoil reclamation research work unit; Chester E. Jensen, retired, formerly principal statistician of the Intermountain Station; Edward L. Noble, a watershed and range management consultant; and John A. Marshall, computer specialist with National Forest Administration, Ketchikan, Alaska.

Single copies of the report are available from the Intermountain Station.

The impact of oil shale development on air quality in western Colorado

In January 1981 a workshop was conducted to discuss the potential impacts of oil shale developments on air quality in western Colorado. It illustrated a general approach to the problem of identifying air quality related values of wilderness areas. Participants included nationally recognized specialists in air quality modeling; in visibility; and in effects of air pollution on soil and water, fish and wildlife, and vegetation.

Reports from the workshop outline an ambitious program of studies necessary in order to protect the Flat Tops Wilderness in western Colorado.

Proceedings from the workshop will be of interest to all federal land managers involved with Class 1 area protection and other air resource responsibilities. For a copy, contact the Rocky Mountain Station and request *Air Quality, Oil Shale, and Wilderness - A Workshop to Identify and Protect Air Quality Related Values of the Flat Tops*, General Technical Report RM-91, by Douglas G. Fox, Dennis J. Murphy, and Dennis Haddow.

A new weapon in the spruce budworm battle

The spruce budworm is a major defoliator in Douglas-fir and subalpine fir forests of western Montana, feeding throughout thousands of acres each year. Repeated, heavy defoliation can cause reduced growth rates, poor timber quality, regeneration failures, top-kill, and even death of the trees.

At the Intermountain Station, scientists have developed a method to help determine the effect of the western spruce budworm on conifer regeneration and growth of new young stands. It depends on measuring the growth rings of old trees on which the budworm has fed (host trees), and comparing the growth ring width (radial growth) to similar measurements from trees not defoliated by the budworm (non-host trees). A comparison of the width of the growth rings between host and non-host trees is the key measurement. The system, developed by Clinton E. Carlson and Ward W. McCaughey, is called "radial increment analysis." The method shows the intensity of outbreaks in the past and how frequently they have occurred. The estimates can be used to determine site and stand conditions that lead to budworm outbreaks and thus which forested areas may be most vulnerable to damage.

Single copies of *Indexing Western Spruce Budworm Activity through Radial Increment Analysis*, Research Paper INT-291-FR-32, are available from the Intermountain Station.

Measuring the effectiveness of outdoor recreation programs

The growing use of public outdoor recreation areas and strong public support for resource preservation efforts by the federal government has spurred the development and expansion of public outdoor recreation programs.

In December 1979 a workshop on recreation output measures was held at Harper's Ferry, West Virginia to help determine ways to measure the effectiveness of these programs. Sponsored by the USDA Forest Service, Bureau of Land Mangement, and George Washington University, the workshop brought together outdoor recreation policy makers and managers from around the country. The group covered needs of the workshop, needs for an evaluation framework, common terminology, measurement and valuation inputs, plus other important points concerning outdoor recreation programs.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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☐*Burning by Prescription in Chaparral,* GTR-PSW-51.
☐*Using Goats to Control Brush Regrowth on Fuelbreaks,* GTR-PSW-59.
☐*Proceedings of the Symposium on the Ecology, Management, and Utilization of California Oaks,* GTR-PSW-44.
☐*A Homeowner's Guide to Fire and Watershed Management at the Chaparral/Urban Interface,* (unnumbered publication).
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Proceedings from this workshop have now been published in a new report titled *Measuring and Improving Effectiveness of Public Outdoor Recreation Programs*, compiled by B.L. Driver and D.H. Rosenthal. If you would like a copy, request it from the Rocky Mountain Station.

Pictures say it better than words

The accumulation of dead, woody debris on the forest floor can spell big trouble as a fire hazard. The Intermountain Station has recently published three field manuals that can help managers of Montana and nearby Idaho forests deal with the problem.

The manuals contain a series of color photographs showing different levels of downed woody material resulting from natural processes. Each photo is supplemented by inventory data describing the size, weight, volume, and condition of the pictured debris. The guides are designed to help forest managers describe the deadwood on the forest floor, to estimate the amount of such material, and to evaluate its fire hazard. The photos in each report show a variety of fuel situations that exist in several different forest cover types in Montana and surrounding Northern Rocky Mountain areas.

Bill Fischer, research forester in the Fire Effects and Use Research and Development Program at the Station's Northern Forest Fire Laboratory, Missoula, compiled the guides. He says, "Perhaps the strongest feature of the series is the fire potential rating with each photo. Alternative methods for evaluating fire potential are generally unavailable, and those methods that do exist are outdated or not well suited for rating nonuniform fuel situations."

If you would like copies of these photo guides, write to the Intermountain Station for the following: *Photo Guide for Appraising Downed Woody Fuels in Montana Forests: Grand Fir-Larch-Douglas-Fir; Western Hemlock; Western Hemlock-Western Redcedar; and Western Redcedar Cover Types*, General Technical Report INT-96-FR-32, by William C. Fischer.

Photo Guide for Appraising Downed Woody Fuels in Montana Forests: Lodgepole Pine and Engelmann Spruce-Subalpine Fir Cover Types, General Technical Report INT-98-FR-32, by William C. Fischer.

Photo Guide for Appraising Downed Woody Fuels in Montana Forests: Interior Ponderosa Pine; Ponderosa Pine-Larch-Douglas-Fir; Larch-Douglas-Fir; and Interior Douglas-Fir Cover Types, General Technical Report INT-97-FR-32, by William C. Fischer.

Land managers interested in developing photo guides for their areas will find helpful information in *Photo Guides for Appraising Downed Woody Fuels in Montana Forests: How They Were Made*, Research Note INT-299-FR-32, also by Fischer. In this report, Fischer tells how the guides were constructed and provides the techniques used to determine the weight and size class distribution of downed woody fuels. The note also contains the procedure used to rate potential fire behavior of the fuel shown in each photo.

Copies are available from the Intermountain Station.

New tool for managers of lodgepole pine

Position and depth of crown canopies of lodgepole pine forests have important connotations for several resource values, including timber, water, and wildlife cover. Crown models recently developed by scientists of the Intermountain Station provide estimates of vertical crown development as a function of dominant stand height and stand density in even-aged stands. When linked with existing tree and stand projection programs managers can predict future crown and canopy development. With existing knowledge of the relationship of crown and canopy parameters to such factors as wildlife habitat requirements and snow interception and melting, managers can preview the impacts of various management alternatives on these resources.

The models were developed by Dennis M. Cole, research silviculturist, and Chester E. Jensen, formerly principal statistician at the Intermountain Station, now retired. *Models for Describing Vertical Crown Development of Lodgepole Pine Stands*, Research Paper INT-292-FR-32, includes model solutions for representative classes of stand density and height and suggestions for using the models in computerized stand projection programs.

Contact the Intermountain Station for single copies of the report.

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